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Physics-Electrical Hybrid Model for Real Time Impedance Matching and Remote Plasma Characterization in RF Plasma Sources

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For RF plasma sources, impedance matching & plasma characterization is very important for efficient plasma operation. In long pulse operation, particularly with high power (~ 100kW or more) where plasma load may vary due to different reasons (e.g. pressure, power, etc.), online tuning of impedance matching circuit is useful. In many cases, manual tuning is not feasible in real time. In some cases matching quality is found out indirectly by phase value cos (ϕ), between RF output voltage and corresponding current. It has been found and verified by experiment that cos (ϕ) may not be a true representative of RF impedance matching for efficient RF power coupling with plasma load in an inductively coupled plasma (ICP) source. In ICP plasma load depends on plasma density. Plasma density characterization is an integral activity for source operation. In some cases due to remote interfaces, radio activation and maintenance issues high power probes are not allowed to incorporate in the ion source design for plasma characterization. Therefore, for characterization, more remote schemes are envisaged. Using electrical parameter one scheme is described [1] to estimate plasma density. Heat load dissipated in the RF antenna can be estimated from the cooling circuit associated with the antenna. Which can be a representative of impedance mismatch with plasma load. Measuring mismatch in the plasma load impedance by using calorimetric data using air-core transformer model for matching [2] can be another alternative procedure. Both the schemes are based on air core transformer model and some limitations are present in the model, which are also discussed in those references. To overcome some of the issues, one physics based code *HELIC* [3] is linked with the model to study the influence of the RF field interaction with the plasma to its impedance.

In this work we shall present the physics-electrical coupled model based on wave-antenna spectrum coupling in the perspective of both automatic remote RF tuning & plasma characterization. This model can be useful for both type of RF sources i.e. ICP & Helicon sources.

References

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